Is goat milk a better milk replacement to piglets, rat pups and foals than cow milk is?

By
Viveca Orve

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Is goat milk a better milk replacement to piglets, rat pups and foals than cow milk is?

Är getmjölk bättre än komjölk som mjölkersättning till griskultingar, råttungar och föl?

Viveca Orve
Supervisor: Sigrid Agenäs at the Dept. of Animal Nutrition and Management
Examinator: Maria Åkerstedtat the Dept. of Animal Nutrition and Management

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Abstract

One opinion among people who are experienced in hand rearing newborn mammals is that goat milk is more suitable than cow milk if the young needs a milk replacer. The purpose of this literature review was to find out if there is scientific evidence that goat milk is a better milk replacer for piglets, rat pups and foals than cow milk. The milk is essential for the newborn animal, as its only source of nutrition until it has learned how to eat solid food. In this literature review, the composition of goat milk and cow milk is compared with the nutrient requirements after birth in piglets, rat pups and foals. The nutrient requirements and the milk composition are partly determined by the newborn mammals activity level and suckling frequency, which also is described. The comparison between goat milk and cow milk showed that the compositions of the two milks is very similar, although there are some small differences which make the goat milk more easily digested for monogastric animals. The higher digestibility leads to a higher absorption of nutrients which in turn leads to a more efficient utilization of nutrients. The subject of milk allergy is also discussed briefly.

Sammanfattning

En åsikt hos människor som har erfarenhet av att flaskuppföda nyfödda djurungar är att getmjölk är lämpligare än komjölk som mjölkersättning. Syftet med den här littereraturstudien var att ta reda på om det finns vetenskapliga bevis för att getmjölk är bättre än komjölk som mjölkersättning till griskultingar, råttungar och föl. För att ta reda på hur det förhåller sig i det fallet jämförs kompositionen hos getmjölk och komjölk med näringsbehovet hos griskultingar, råttungar och föl. Mjölken är essentiell för den nyfödda ungen eftersom innan den lärt sig äta fast föda utgör mjölken dess enda näringskälla. Näringsbehoven och mjölksammansättningen bestäms delvis av ungens aktivitetsnivå och difrekvens, och därför beskrivs också dessa. Jämförelsen mellan getmjölk och komjölk visade på att kompositionen är väldigt likartad, sånär som på några små skillnader som gör getmjölken mer lättsmält för enkelmagade djur. Den högre smältbarheten leder till en högre absorption av näringsämnen vilket i sin tur leder till ett mer effektivt utnyttjande av näringsämnen. Orsakerna till mjölkallergi diskuteras i korthet.

Introduction

The first period after birth is the most critical period in the life of a mammal. During that time milk plays a vital role. Until the young mammal has learned to eat solid food it gets all the nutrition it needs from the milk (Björnhag et al., 1996; Penchev, 2008). That is why it is so important to have an effective milk replacement if the young mammal for some reason is unable to suckle its mother. This literature review deals with nutrient requirements in piglets, rat pups and foals during the first weeks after birth. The reason for choosing piglets and rat pups was because they have been used in most of the research, and since I have heard that cow milk is a bad milk replacement to foals, I thought it would be interesting to find out if goat milk would be better. The nutrient requirements and the species specific milk composition are partly determined by the newborn mammals activity level and suckling frequency, which is also described.

When it comes to choosing a milk replacement for a newborn animal, there are several factors that need to be taken into consideration. Factors like the suckling frequency, nutrient composition and presence of components that may cause problems and even allergies in the metabolism of the newborn mammal. This means that the efficiency of a milk replacement is case-to-case sensitive;

a certain milk replacement could be very effective for one type of animal and totally wrong for another (Röken, pers. com. 2009).

The traditional milk used in milk replacements for mammals is cow milk (Rutherfurd et al., 2006); though goat milk is sometimes used. One opinion among people who are experienced in hand rearing newborn mammals is that goat milk is more suitable than cow milk for use in a milk replacement. Could it be that goat milk is better? The aim of this literature review was to compare the composition of cow milk and goat milk in order to find out the differences between them. Also to find out if there is scientific evidence that goat milk is a better replacement for piglets, rat pups and foals than cow milk is.

Milk replacement

The milk replacement is supposed to replace the mother's milk and thus support the young mammal until it has learned how to eat solid food (Penchev, 2008). Therefore the nutrient composition is very important. It must meet the nutritional needs of the newborn animal and provide energy just like the natural milk, and in the case of a colostrum replacer, provide antibodies and growth factors (Thymann et al., 2006).

Colostrum

Colostrum is the first milk produced after birth. The colostrum provides antibodies from the mother and gives the newborn animal protection against some infectious diseases. The concentration of antibodies has its highest value in the first colostrum (Penchev, 2008). It is therefore crucial that the newborn mammal gets this early colostrum, since the concentration of antibodies in colostrum will decrease rapidly after the first day (Rauprich et al, 2000). Also the permeability of the small intestine, for large molecules like the antibodies, will only last for short time, and how long that is differs between species. In the calf the intestinal permeability lasts for about 36 hours after birth but for a lamb it lasts for three days (Penchev, 2008). The colostrum also contains hormones and growth factors which are supposed to stimulate the growth and development of the digestive system of the newborn animal (NRC, 2001). Commercial replacers for colostrum to calves contain cow antibodies in an amount which should lead to a sufficient uptake. However, the efficiency of uptake seems to vary between formulas (Godden et al., 2009). Godden et al., (2009) thought that it might be due to differences in quality i.e. differences in the production and the testing procedure, or that the amount of antibodies supplied to the milk is not enough for a satisfactory uptake.

Nutrient requirements for newborn mammals

The nutrient requirements are basically the same for all newborn mammals; they require protein fat, minerals (major and trace minerals), carbohydrates and vitamins. Protein is needed both in quantity and in the form of essential amino acids, present in the food. Essential amino acids can not be synthesised by the monogastric animal so they must be supplemented through the diet. For bone formation the young mammal requires calcium and phosphorus. Iron is also very important since it is crucial in the formation of haemoglobin. The primary purpose of fat is that it should provide the young mammal with energy, but some fatty acids also have specific functions in the body. Energy is also provided in the form of carbohydrates, like lactose and glucose (McDonald et al., 2002).

Nutrient requirements of the young calf and goat kid

Ruminant milk is adapted to meet the needs of the newborn ruminant (for composition of the milk, see table 1). From the moment the ruminant is born to the time when it is weaned the digestive system undergoes a remarkable transformation; the change of the gastrointestinal tract from that of a single stomached animal to that of a ruminant. It is very important with a suitable diet during this time when the rumen and the other forestomachs develop. Even though the ruminant gets most of the nutrition it needs from the colostrum, and later the milk, it should have access to fibers for stimulation of the development of the rumen (NRC, 2001). It is vital that the diet has a good source of protein so that the calf and the goat kid can grow, and that essential amino acids are provided (NRC, 1981; NRC, 2001). As soon as the rumen is fully developed, the young ruminant receives practically all of the protein it needs from the activity of the microorganisms (NRC, 2001; NRC, 1981). Both animals need to be supplemented with vitamin A, D and E through the feed while the rumen microorganisms synthesise vitamin K and vitamin B complexes (NRC, 2001; NRC, 1981). The requirement of different minerals in the young calf has not been studied very much in recent years, though the recommended degree of calcium and phosphorus in milk replacements has been increased to better resemble the concentration of calcium and phosphorus in milk (NRC, 2001). Goat kids have a lower requirement of calcium and phosphorus than calves (Meschy, 2000).

Nutrient requirements of the piglet

The amino acids which are essential to all pigs are histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine (McDonald et al., 2002). The piglet has got very low levels of fat when it is born (Bee, 2000). So, during the first time after birth, the fat in the milk is particularly important, together with lactose, for providing energy (Bee, 2000). For composition of the milk see table 1. Polyunsaturated fatty acids (PUFA) are important when it comes to the normal functioning of the immune system; the presence of some PUFA seem to result in a lessening of the production of inflammatory associated signal molecules (Leskanich and Noble, 1998). As for minerals, iron is a very important mineral for young piglets; owing to the fact that iron is essential for the development of haemoglobin as well as in many of the enzymes (McDonald et al., 2002). In nature the piglets would acquire iron through contact with soil. However, most piglets today are born indoors, and not out on the ground, meaning that the opportunity to obtain iron that way is virtually nonexistent. To counteract this and to prevent anaemia, piglets must be supplemented with additional iron (NRC, 1998). A piglet that is still suckling requires 7 – 16 mg iron per day, or 21 mg of iron per kg of body weight to be able to sustain enough iron for production of haemoglobin and storage in the body (NRC, 1998).

Nutrient requirements of the rat pup

The protein requirement of the young rat declines after it is weaned (NRC, 1995). Like all mammals the young rat requires iron for the production of haemoglobin and calcium and phosphorus in order to be able to build a good and strong skeleton. Lipids are important as they provide the young rat with essential fatty acids. In addition to providing energy, the fatty acids facilitate the absorption of nutrients by improving the stomachs acceptability of different nutrients (NRC, 1995).

Nutrient requirements of the foal

The protein content of the mare's milk is highest in the beginning (Planck & Rundgren, 2003). For composition of the milk, see table 1. Protein is needed for growth of muscles, connective tissues and total body mass, and the foal needs to grow quickly in order to be able to escape predators. Lysine is a limited amino acid to foals. Both the protein content of the milk and the growth rate decreases as the foal gets older (Csapó et al., 1994; Planck & Rundgren, 2003). Horses also require vitamins although not in very high amounts, and as in the case with ruminants, the microorganisms in the horse's large intestine can synthesise several of the vitamins needed. When it comes to fatty acids horses do not appear to have very high requirements, a part from linoleic and linolenic acid. The need for calcium and phosphorus are highest during the first year since that is when the major part of the skeleton growth occurs. Due to that the horse looses a lot of salt through sweating it should always have access to a salt stone to lick at. Too much salt, however, can cause diarrhoea in foals (Planck & Rundgren, 2003). The foal is very active and requires a lot of quick energy in the form of lactose (Björnhag et al., 1996).

Table 1. The composition (%) of cow, goat, sow, rat and horse milk

	Fat	Protein	Lactose	reference
Cow milk	3,4	2,9	4,5	Ceballos et al., *In Press*
Goat milk	5,2	3,5	4,1	Ceballos et al., *In Press*
Sow milk	7,6	5,5	5,3	Ivarsson, E. 2007
Rat milk	10,3	8,4	2,6	Alfa Laval Agri AB, 1995
Horse milk	1,9	2,1	6,4	Planck & Rundgren, 2003

Suckling frequency

There is a clear connection between the activity level and suckling frequency of the newborn animal and milk composition. Young animals are usually followers or hiders. If the animal is a follower it follow its mother all the time and if it is a hider it lies hidden the first weeks after birth and only has contact with its mother when it is time to suckle. By studying the composition of the milk, one can get a hint about if the young animal is a follower or a hider (Björnhag et al., 1996). The foal for example, is a typical follower; because of this it has got quite a high activity level and suckling frequency. In response the milk of the mare has a very high level of lactose and low levels of fat and protein. In the first week after birth the foal suckles seven to eight times in one hour (Planck & Rundgren, 2003). The high suckling frequency compensates for the low nutritive value of the milk and insures that the foal gets all the nutrition it needs. The purpose of the high lactose level is to provide energy so that the foal can run with its mother. Thus the milk of follower-animals is characterized by a low level of dry matter and high water content. Because the young is so active it needs the water to compensate for the losses of water through temperature regulation. Animals can also be hiders; consequently the suckling frequency is low and so is the level of activity. The goat kid is a hider; the newborn goat kid stays hidden and the mother comes only three or four times a day to feed it (Bakken et al., 2003). Due to this the milk has high levels of fat and protein and low lactose content. The high levels of fat and protein is for maintenance and growth, and since the young goat kid has a low activity level, it does not need the quick energy of lactose (Björnhag, 1996). To make sure that the newborn animal gets as much nutrition as possible, the nutrients of the milk have been concentrated to maximize the nutritional gain. Due to that the newborn is still most of the time, it does not need a lot of water to regulate the temperature (Björnhag et al., 1996).

There are also some species that are neither hiders nor followers; a good example of this is the calf. During the first two months after birth the calf behaves like a hider, lying hidden in the grass waiting for its mother, but after these months the calf is following its mother (Jensen, 2006). Accordingly the suckling frequency is somewhat between that of the foal and the newborn goat, around 4-5 times a day (Jensen, 2006). The composition of the milk is also between that of a follower and a hider; having average levels of protein, fat and lactose (Björnhag et al., 1996).

Goat milk versus cow milk

Protein content

The proteins present in milk can be divided into two groups; caseins, (alfa-s1-casein, alfa-s2-casein, beta-casein, kappa-casein) and whey proteins (alfa-lactalbumin and beta- lactoglobulin). See table 2 for an average amount of each protein fraction.

Table 2. Protein fractions in goat and cow milk (based on values from Ceballos et al., *In Press)*

	Content (%) 100 g protein	
Protein fraction	goat	cow
alfa-s1-casein	18,92	30,80
alfa-s2-casein	8,52	7,50
beta- and kappa-casein	55,26	44,35
whey proteins	17,30	17,35

The caseins generally account for the majority of the protein content (80%) in both cow milk and goat milk while the whey proteins account for the rest (20 %) (Walstra & Jenness, 1984). Then again there is a large genetic variation within species, and there are cows and goat that barely produce any casein at all (Haenlein, 2001). The proteins are the same between goat milk and cow milk, although the proportion of each protein differs due to different levels of polymorphism. Within the milk proteins in the goat milk there is a higher level of polymorphism than in the cow milk proteins, especially among the alfa-caseins (Haenlein, 2004). Six different variants of alfa-s1-casein have been identified in goat milk, as well as a “null”-allele (when a goat is homozygous for this allele it do not express alfa-s1-casein at all). The frequency of each individual allele determines the total amount of the protein. The caseins form micelles, (molecules in the structure of a ball, with the fat soluble ends in the center and the water soluble ends against the surrounding water) (Ophardt, 2003) in the milk, which bind calcium and phosphorus (Jenness, 1980). The casein micelles of goat milk are quite different from the casein micelles of cow milk.

The goat milk micelles are smaller, contain more calcium and phosphorus, are less stable towards heat, have a lower sedimentation rate, a lower solvation which is the process in which a molecule is surrounded by solvent molecules arranged in a specific manner (Chang, 2005) and the solubility of the beta-casein is larger (Haenlein, 2004). The smaller size of the casein micelles results in softer and more easily digested coagulate in the stomach (Ceballos et al., *In Press).* The softer coagulate facilitates for the protease enzyme to do its work, which gives an improved digestibility. A coagulate consists of casein micelles clotted together due to the influence of rennet (Jonsson, 2003). Lopez-Aliaga et al., (2003) did a study in rats with intestinal resection on the nutrient utilization of protein and magnesium. The rats were fed either goat milk or cow milk. The result was that the protein utilization was higher in the rats fed goat milk.

As a result of the presence of the null-allele in goat milk, the alfa-s2-casein is the dominant casein; in contrast to cow milk where alfa-s1-casein is the dominant one (Haenlein, 2004). That could be one of the reasons why cow milk is more allergenic than goat milk; Roncada et al., (2002) believes that milk allergy is caused by a specific variant of the alfa-s1-casein. Studies on guinea pigs (Haenlein, 2004) given goat milk with a variant of alfa-s1-casein, similar to the variant in cow milk, and a goat milk with alfa-s2-casein instead, showed a much smaller allergic response to the milk with the alfa-s2-casein. However, more resent studies (Niemi et al., 2007; Lam et al., 2008) have shown that the whey proteins, and especially beta-lactoglobulin, are just as allergy causing as the caseins.

There is genetic polymorphism among the beta-caseins as well; more so in goat milk than in cow milk. Like in alfa-s1-casein there is a null-allele (Persuy et al., 1999). Rocanda et al., (2002) reckons that beta-casein helps to stimulate the autoimmune response. For the whey proteins, alfa-lactalbumin and beta-lactoglobulin, the structure is similar for both milks (McCullough, 2003).

Fatty acid content

The fat in goat and cow milk consists of saturated, monounsaturated and polyunsaturated fatty acids. Caproic, caprylic, and capric acid are very characteristic for goat milk, and have in fact been named after the Latin name for goat. These three fatty acids are found in cow milk as well but not to the same extent (Haenlein, 2004). The amounts of the individual fatty acids can be found in table 3. The fatty acids are present in the milk as fat globules, and the fat globules of goat milk are a lot smaller than the globules in cow milk (McCullough, 2003). In the stomach the fat globules of cow milk tend to form clusters which are hard to digest, but because of their smaller size, the globules in goat milk tend to blend with the rest of the milk rather than forming clusters, which makes it easier for the lipase enzymes to do their work and thus contributing to a better digestibility (McCullough, 2003).

The fat of goat milk is much more easily digested and metabolized than the fat of cow milk (Ceballos et al., *In Press*) in monogastric animals; the reason for that is that goat milk has a much higher proportion of triglycerides with medium chain fatty acids. The enzyme salivary pregastric lipase hydrolyzes the triglycerides containing medium chain fatty acids already in the stomach, so that they do not need to be reestrified before being absorbed. The following oxidation is also faster, resulting in useful sources of energy in a very short time and in all a more efficient utilization of these fatty acids (Leyton et al., 1987; Matsuo & Takeuchi, 2004). Therefore they are digested and utilized in a much more efficient way (Matsuo & Takeuchi, 2004) than the triglycerides with longer fatty acids.

Table 3. The average fatty acids in goat and cow milk (based on values from Ceballos et al., *In Press*)

	Content in (%) 100 g milk	
Fatty acid	goat	cow
saturated		
C4:0 (butyric acid)	0,067	0,12
C6:0 (caproic acid)	0,17	0,078
C8:0 (caprylic acid)	0,19	0,058
C10:0 (capric acid)	0,58	0,11
C12:0 (lauric acid)	0,23	0,14
C14:0 (myristic acid)	0,52	0,38
C16:0 (palmitic acid)	1,35	1,10
C18:0 (stearic acid)	0,49	0,38
monounsaturated		
C16:1 (palmitoleic acid)	0,052	0,052
C18:1 (oleic acid (total))	1,26	0,80
polyunsaturated		
C18:2 n-6 (linoleic acid)	0,14	0,082
CLA total	0,036	0,016
C18:3 n-3 (linolenic acid)	0,028	0,008

In total the ratio between saturated and unsaturated fatty acids are almost the same in goat and cow milk but there is a higher amount of polyunsaturated fatty acids (PUFA) in goat milk (Haenlein, 2004; Ceballos et al., *In Press*). PUFA are important when it comes to the normal function of the immune system. Also PUFA seem to have beneficial effects the growth and development of a newborn mammal (Leskanich & Noble, 1998). One type of fatty acids is conjugated linoleic acids (CLA); these are found in all ruminant milk (Griinari et al., 2000) but in different forms and with a higher proportion in goat milk than in cow milk (Ceballos et al., *In Press*).

Murry et al. (1999) did a study with newborn piglets fed either goat milk or cow milk, in order to see if there were any differences concerning growth, digestibility of nutrients and body composition. The results suggested no significant differences between the two milks, in their effect on piglet growth and body composition, although noteworthy differences in the plasma concentration of certain fatty acids could be observed. The piglets which had been fed the goat milk diet showed distinctly higher levels of capric acid and lauric acid in plasma compared to the piglets fed cow milk. They also showed higher plasma levels of magnesium, zinc and sodium.

Mineral content

A comparison of the mineral content of the two milks showed higher content of calcium, phosphorus, magnesium, iron, copper and zinc in goat milk than in cow milk (see table 4) (Ceballos et al., *In Press*).

Table 4. The content of some minerals in goat and cow milk (based on values from Ceballos et al., *In Press*)

	Content in (%) 100 g milk	
Minerals	goat	cow
calcium	0,16	0,11
phosphorus	0,12	0,087
magnesium	0,013	0,009
iron	0,00015	0,00009
copper	0,000042	0,000014
zink	0,00053	0,00046

Rutherfurd et al., (2006) did a study on mineral retention in three week old piglets fed goat and cow milk based formulas. The digestibility and absorption of minerals varied between the two formulas. There were no significant differences, except for the uptake of manganese which were higher for the goat milk based formula, in the visible absorption of the minerals. The piglets fed the goat milk based formula showed the highest retention of calcium (Rutherfurd et al., 2006). Campos et al., (2007) studied the effects of goat and cow milk on the utilization of calcium and phosphorus in rats with intestinal resection. The result showed that the apparent digestibility of calcium and phosphorus was highest in rats fed the goat milk based formula; this was probably due to the higher amount of triglycerides in the goat milk, which has a positive effect on the utilization of calcium and phosphorus (Campos et al., 2007). Barrionuevo et al., (2002) did a similar study on the nutritive utilization of iron and copper in rats with malabsorption syndrome. The result was the same; the rats fed the goat milk diet showed a higher apparent digestibility of the minerals compared to cow milk. The iron retention was also higher in the rats fed goat milk diet. In a study done by Lopez-Aliaga et al., (2003) on rats fed either goat milk or cow milk, the results showed a higher absorption and utilization of magnesium in the rats fed goat milk.

Discussion

When it comes to milk replacements for piglets, I would say that goat milk appears to be a better alternative. Firstly, the value of amino acids essential to pigs seems to be higher in goat milk (Ceballos et al., *In Press*). Piglets also need extra supplementation of iron after birth and goat milk has a higher iron content compared to cow milk (Ceballos et al., *In Press*). In the study done by Murry et al., (1999) the piglets fed goat milk had higher plasma levels of iron than those fed cow milk. However, in the study done by Rutherfurd et al., (2006) the iron retention and absorption was higher for the cow milk based formula. The cow milk based formula was enhanced with whey protein which meant that it was processed differently compared to the neutral goat milk. Rutherfurd et al., (2006) suggested that the different preparations resulted in dissimilar amounts of minerals available for absorption. The fat in goat milk contains higher amounts of PUFA, compared to the fat in cow milk. PUFA have beneficial effects on the growth rate, and the normal functioning of the immune system in pigs. The content of CLA is also higher and according to the studies done by Bee (2000) and Leskanich & Noble (1998) CLA and other polyunsaturated fatty acids have a positive influence on the piglet's development.

The sows in the study done by Bee (2000) had received extra supplementation of either CLA or ordinary linoleic acid. The piglets which had suckled the sows fed CLA had higher feed intake and higher growth rate per day than the others. Although the piglets received the extra CLA through the milk of the sow, it seems possible that piglets fed goat milk, with high values of CLA, would benefit the same way. As for negative effects of milk replacements Thymann et al., (2006) did a study on what the immediate reaction was in the gastrointestinal tract of newborn piglets fed either colostrum from its own mother or a cow milk based formula. The result of the study was that the piglets fed the formula developed a reduced capacity to digest lactose, due to low levels of the lactase enzyme. The low levels were probably due to malfunction of the gut (Thymann et al., 2006).

As milk replacement to rat pups goat milk indeed seems to be better. The absorption and utilization of minerals are much higher compared to cow milk (Barrinuevo et al., 2002; Campos et al., 2003; Lopez-Aliaga et al., 2003). Also the easily broken down and digested fat should be beneficial for the rat pup. It has been difficult to find information about the nutrient requirements of the rat pup during the first weeks after birth, because of the lack of information in the literature. Nevertheless, considering that rat milk has quite a high protein content it is reasonable to assume that rat pups have got a high requirement of protein. Also they are born furless, which could explain the high fat content of the milk. Until they had grown a fur they would need a lot of energy to keep the warmth up.

There is an opinion among people that work with horses that cow milk is not a good milk replacement to foals. Could goat milk be a better choice? Goat milk contains high amounts of calcium and phosphorus which are, due to the better digestibility, easily absorbed. As for lactose neither goat milk nor cow milk has very high lactose content, the energy instead being present as fat, and according to Ceballos et al., (*In Press*) the level of lactose is actually higher in cow milk. Due to this it seems unlikely that goat milk would be better. Although, the fat of goat milk with its high content of medium chain fatty acids, and small fat globules, is more easily digested than the fat of cow milk, which means that it should take less time to acquire useful sources of energy. The foal's requirement of a high lactose level in the milk makes it difficult to produce an efficient milk replacement. The best solution is probably to mix different milks and add extra lactose. It would have been interesting to find information about why cow is no good for foals but it is most likely due to the insufficient amount of lactose.

Goat milk seems to be less allergenic than cow milk due to the polymorphism among the alfa-s1-caseins. Considering Roncadas (2002) theory about milk allergy being caused by a specific variant of alfa-s1-casein and the fact that the guinea pigs (Haenlein, 2003) showed a much smaller allergic response to goat milk without alfa-s1-casein, there seems to be a connection. My own theory is that because one of the alleles of alfa-s1-casien in goat milk is a null-allele, the protein is not expressed as much as in cow milk; and since goat milk contains less alfa-s1-casein, the smaller the probability, that the presumed alfa-s1-casein variant, causing the allergy, is expressed. However, more recent studies have showed that the whey proteins are just as allergy causing as the caseins (Niemi et al., 2007; Lam et al., 2008), and that is just the thing; allergy is so complex and so it can be caused by several factors. Also it depends from case to case whether it will be an allergic reaction or not; depending on whether the immune system recognizes the milk proteins as harmless or if it experiences them as a threat which must be destroyed.

Goat milk as a milk replacement seems to have some advantages, primarily when it comes to the digestibility. The smaller size of the casein micelles results in a more easily broken down coagulate in the stomach (Ceballos et al., *In Press*), and a more efficient digestibility leads in turn to a better utilization of nutrients (Murry et al., 1999; Rutherfurd et al., 2006; Campos et al., 2007). Also, the high amount of medium chain fatty acids result in useful sources of energy in a short time. Furthermore goat milk contains higher amounts of the main minerals which are more easily accessible due to the better digestible. But then, if that is the case, why is not goat milk used more often in milk replacements? Maybe it all comes down to tradition? Could it simply be that because cow milk is the traditional milk used in milk replacements, people use it out of habit? Or is it because cow milk is easier to obtain than goat milk?

Milk production is a major industry in the world, and some of the excess fresh milk is often sold as milk powder to be used in milk replacements. In the west world cow milk is the most common milk and that could be a possible explanation to why cow milk is a common milk replacer for other species. Goat milk is not so easily accessible. It is strange that there is so little research done about milk replacers when they play such an important role in the survival of newborn mammals. Take dogs for example, 60,000 pure breed puppies are registered in Sweden each year at least some of them will have to be fed a milk replacement. If the milk replacement is not effective the puppies will die and the breeder will lose money. So it is very important to have a good knowledge about suitable milk replacements and I strongly suggest further research about goat milk as an alternative milk replacement to other animals than piglets and rats. Another area for further research is the nutrient requirements for newborn animals during the first weeks because it has been very difficult to find much information about the nutritional needs of the rat pup for example.

Conclusion

The composition is very similar between the two milks, but goat milk is more easily digested for monogastric animals, which results in a better nutritional value. In spite of that, goat milk is not used as a milk replacer as often as could be expected in the view of the benefits. Goat milk seems to be a better milk replacement than cow milk to piglets, and rats, but whether it is better in general is difficult to say because of the lack of information in literature.

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